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Designing ion energy distributions to control aluminum oxide growth by reactive magnetron sputtering

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Ion bombardment is crucial for many low-pressure plasma synthesis processes. The control of the ion energy leading to a specific dissipated energy per incorporated atom in the film enables the formation of metastable phases, which cannot be synthesized by conventional methods. It is also known that specific ion energies are necessary to promote subplantation, formation of interstitials or to avoid undesired sputtering effects. However, the correlation between the exact nature of the ion energy distribution function and the resulting film properties remains largely unexplored. This contribution presents new concepts to design and shape the ion energy distribution by applying substrate biases with adjustable waveforms. The ion energy distributions are simulated based on a plasma sheath model as well as directly measured on the biased electrode. The influence of a designed shape of the ion energy distribution on the material properties is illustrated for the example of alumina deposition in reactive magnetron sputtering. It is shown that the crystalline orientation depends sensitively on the choice of the ion energy distribution. This interplay is compared to modeling approaches based on the binary collision approximation. The plasma experiments are completed by particle beam experiments to analyze the surface processes during ion-induced aluminum oxide formation more directly.

Keywords
alumina
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surface processes